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Updating emotional content in working memory: A depression-specific deficit?

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ABSTRACT

Background and objectives: Interference from irrelevant negative material might be a key mechanism underlying intrusive ruminative thoughts in depression. Considering commonalities between depression and social anxiety and the presence of similar intrusive thoughts in social anxiety, the current study was designed to assess whether interference from irrelevant material in working memory is specific to depression or is also present in social anxiety disorder.
Methods: To examine the effects of irrelevant emotional material on working memory performance, participants memorized two lists of words on each trial and were subsequently instructed to ignore one of the lists. Participants were then asked to indicate whether a probe word belonged to the relevant list or not.
Results: Compared to control and social anxiety groups, the depression groups (both pure and comorbid with social anxiety disorder) exhibited greater difficulties removing irrelevant emotional material from working memory (i.e., greater intrusion effects). Greater intrusion effects were also associated with increased rumination.
Limitations: Although we included three clinical groups (depression, social anxiety, and the comorbid groups), the results are based on a relatively small number of participants.
Conclusions: The results indicate that difficulties removing irrelevant material from working memory might be unique to depression, and the ability to inhibit irrelevant information is relatively preserved in social anxiety disorder.

Introduction

Depression is characterized by recurrent, unintentional, and uncontrollable ruminative thoughts, which predict the onset and recurrence of depressive episodes (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Therefore, understanding mechanisms associated with increased rumination is critical to improving our understanding of depression. Recently, deficits in working memory and related executive processes (e.g., updating or inhibiting information in working memory) have been proposed as key mechanisms underlying intrusive thoughts in depression (Joormann, 2010). Working memory is a limited-capacity system responsible for the temporary maintenance and manipulation of information relevant to current tasks and goals (Baddeley, 1996). Given these capacity limitations, cognitive inhibition is critical to efficiently update the contents in working memory, thereby facilitating working memory functioning (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). When inhibitory mechanisms do not function efficiently, too much irrelevant information occupies working memory (Hasher, Zacks, & Rahhal, 1999). Such deficits in cognitive inhibition might lead individuals with depression to dwell on negative content and exhibit enhanced retrieval of negative, yet irrelevant, information, thereby perpetuating depressed mood.

To examine whether depression is associated with deficits inhibiting previously relevant, but currently irrelevant information, Joormann and Gotlib (2008) used the modified Sternberg task (Oberauer, 2001). During the modified Sternberg task, participants first memorized two lists of words, followed by a cue indicating which of the two lists was relevant for the recognition task in the

Abbreviations: MDD, major depressive disorder; SAD, social anxiety disorder; COM, comorbid; CTL, control.

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next display. Participants' main task was to indicate whether or not the final probe came from the relevant list. Individuals with major depressive disorder (MDD) exhibited difficulties inhibiting irrelevant negative – but not positive – material. Importantly, greater difficulty removing irrelevant negative material was associated with the tendency to ruminate.

Recurrent unintentional thoughts are also prominent in anxiety disorders, with intrusive thoughts predicting maintenance of anxiety symptoms (e.g., Nolen-Hoeksema, 2000; Segerstrom, Tsao, Alden, & Craske, 2000). Thus, working memory-related deficits may not be specific to depression and could play an equally important role in anxiety disorders. Indeed, the processing efficiency theory (Eysenck & Calvo, 1992) and its refined version, the attentional control theory (Eysenck, Santos, Derakshan, & Calvo, 2007), argue that repetitive, intrusive thoughts in anxiety are associated with inhibition deficits. Although some studies reported working memory deficits in anxiety (see Derakshan & Eysenck, 2009 for review), other studies found no anxiety-related deficits or even demonstrated that anxiety is associated with enhanced performance on working memory tasks (e.g., Birk, Dennis, Shin, & Urry, 2011).

Interestingly, the attentional control theory (Eysenck et al., 2007) leaves room for anxious individuals to exhibit a level of performance equivalent to controls on working memory tasks. According to this theory, anxiety can serve a motivational function leading to greater effort to meet task goals. As a result, anxiety might attenuate, or even reverse, the expected performance deficits due to impaired inhibition of internal (e.g., worries) or external threat-related stimuli. Thus, anxiety may have different effects on two indicators of working memory function, effectiveness and efficiency. Whereas effectiveness concerns the quality of working memory task performance often reflected in response accuracy, efficiency concerns the amount of effort or resources spent to attain a given performance level and is typically assessed by response latencies. The attentional control theory posits that anxiety might impair the efficiency of working memory, but performance effectiveness might be intact if anxious individuals use compensatory strategies such as enhanced effort when performance is at least partly dependent on effort (Hayes, MacLeod, & Hammond, 2009). Findings from a recent study (Hayes et al., 2009) support this proposition. Under an incidental learning condition where participants' effort has little effect on performance, anxiety-related deficits were present. However, anxious individuals did not differ from their less anxious counterparts under an intentional learning condition where participants could direct their effort according to explicit rules. Thus, although limited, evidence indicates that anxious individuals might exhibit comparable levels of performance as controls if (a) the outcome focuses on the effectiveness of working memory and (b) the nature of a task allows performance to be influenced by effort.

In the Sternberg task, longer reaction times (RTs) to reject irrelevant probes (i.e., reduced efficiency) have typically been viewed as the indicator of cognitive inhibition deficits. Deficits in cognitive inhibition, however, also can emerge as lower accuracy rates when rejecting an irrelevant probe (i.e., reduced effectiveness). In Joormann and Gotlib's study (2008), the task permitted participants as much time as they needed, thereby reducing or even eliminating any group differences in accuracy rates. In the current study, however, participants were given 3 s to respond to probes, thereby eliminating ceiling effects in accuracy rates and allowing any potential group differences in accuracy rates (i.e., effectiveness) to emerge. This critical change was introduced in order to examine both efficiency and effectiveness of working memory.

The goal of the present study was to examine whether deficits in cognitive inhibition are specific to MDD or are also present in social anxiety disorder (SAD) using a task that allows an examination of both efficiency and effectiveness. We decided to compare MDD and SAD for several reasons. First, these disorders are highly comorbid, with 56% of individuals with a principal diagnosis of MDD meeting criteria for comorbid SAD in a treatment seeking population (Brown, Campbell, Lehman, Grisham, & Mancill, 2001). Second, SAD shares several characteristics with MDD. In fact, SAD is the only type of anxiety disorder that is characterized by low positive affect, which is a key feature of depression (e.g., Brown, Chorpita, & Barlow, 1998). Furthermore, cognitive models of social anxiety (e.g., Clark & Wells, 1995) outline ruminative processes that occur either before (i.e., anticipatory processing) or after (i.e., post-event processing) a social-evaluative situation as one of the key processes that maintain social anxiety. Indeed, individuals with SAD exhibited similar levels of brooding, a particularly maladaptive subtype of rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003) as individuals with MDD (McEvoy, Watson, Watkins, & Nathan, 2013). SAD, therefore, is a good candidate to examine the specificity of inhibition deficits to depression.

Specifically, the study was designed to (a) replicate and extend previous findings demonstrating cognitive inhibition deficits in MDD by looking at both efficiency and effectiveness, (b) examine whether individuals with SAD would also exhibit difficulty inhibiting emotional material, and (c) assess whether individuals with comorbid MDD and SAD would demonstrate inhibition deficits similar to depressed individuals without comorbid SAD. We predicted that individuals with MDD would exhibit reduced cognitive inhibition when processing negative material compared to healthy controls, replicating previous research (Joormann & Gotlib, 2008). Individuals with SAD might also exhibit reduced efficiency in working memory (i.e., longer RTs to reject intrusion probes). Based on the attention control theory (Eysenck et al., 2007), however, we predicted that individuals with SAD would exhibit comparable levels of effectiveness of working memory (i.e., accuracy rates) to controls due to their increased motivation and efforts. That is, despite the fact that both MDD and SAD can be characterized by intrusive thoughts, we expected individuals with SAD to exhibit intact performance *effectiveness* on a task in which deliberate effort could successfully enhance performance and thereby masking any cognitive inhibition deficits.

Method

Participants

Participants were recruited from the greater Miami area through advertisements posted in numerous locations within the community (e.g., Internet bulletin boards, university kiosks) as well as recurring advertisements in a local newspaper. Participants completed a telephone interview, which provided initial selection information. Based on the telephone interview, we excluded participants if they reported severe head trauma or learning disabilities, psychotic symptoms, bipolar disorder, or alcohol or substance abuse within the past 6 months. Participants were also excluded if they were younger than 18 years old, older than 60 years of age, or not fluent in English. Eligible individuals were invited to come to the laboratory for a more extensive interview.

Trained interviewers administered the Structured Clinical Interview for the DSM-IV – Clinical Version (SCID-CV; First, Spitzer, Gibbon, & Williams, 1996) to invited participants during their first visit in the study. All interviewers had extensive training in the use of the SCID and had previous experience in administering structured clinical interviews in a research setting. The SCID has good reliability for the majority of the disorders covered in the interview (Lobbestael, Leurgans, & Arntz, 2011; Skre, Onstad, Torgersen, &

Table 1
Experimental conditions, response latencies, and percentage of correct responses.

Cond	Relevant	Irrelevant	Probe	CTL			SAD			MDD			COM		
				M	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%
1	Positive	Negative	Relevant	1347.97	314.00	83	1312.98	271.00	91	1479.27	297.99	90	1297.33	287.51	77
2	Positive	Negative	Intrusion	1602.24	194.37	80	1526.55	237.61	80	1727.11	263.65	65	1638.70	339.89	63
3	Positive	Negative	New Positive	1203.07	186.10	96	1161.78	270.69	91	1349.18	250.94	92	1271.15	334.39	96
4	Positive	Negative	New Negative	1213.92	202.62	96	1138.88	240.44	91	1336.00	242.44	94	1218.96	293.29	96
5	Negative	Positive	Relevant	1387.77	310.55	86	1418.68	264.97	89	1500.02	293.24	91	1336.69	244.88	84
6	Negative	Positive	Intrusion	1605.39	231.52	78	1590.81	262.36	76	1747.17	270.19	66	1576.51	342.74	65
7	Negative	Positive	New Positive	1222.31	210.89	95	1165.37	251.65	91	1323.53	281.22	92	1196.59	278.00	96
8	Negative	Positive	New Negative	1237.99	163.34	95	1151.08	256.56	91	1368.17	245.30	92	1227.43	286.14	94
9	Mixed	Mixed	Mixed	1437.29	248.55	63	1417.96	230.46	62	1513.30	257.87	58	1330.98	316.72	59

Kringlen, 1991). For the current study, independent raters rated the recorded SCIDs and achieved perfect agreement with the original interviewers ($\kappa = 1.00$).

Participants were included in the depressed group (MDD) if they met the MDD-current criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric, 2000). Participants were included in the social anxiety group (SAD) if they met the SAD-generalized type criteria of the DSM-IV-TR. Participants were included in the comorbid group (COM) if they met the DSM-IV-TR criteria for both MDD and SAD. The never-disordered control group (CTL) consisted of individuals with no current diagnosis and no history of any Axis I disorder. Seventy-four individuals (18 MDD, 17 SAD, 21 COM, and 18 CTL) participated in this study. Twenty-four participants (7 from the MDD, 8 from the SAD, and 9 from the COM groups) had various additional current anxiety disorders (i.e., panic disorder, specific phobia, obsessive–compulsive disorder, generalized anxiety disorder). No other Axis I disorders were present in our participants.

Modified Sternberg task

A modified Sternberg task (Joormann & Gotlib, 2008; Oberauer, 2001) was used in this study. Each trial started with a fixation cross, which appeared for 500 ms, followed by three separate displays: a learning display, a cue display, and a probe display. In the learning display, two lists of three words each were presented simultaneously. The words in one list were presented in blue, and the words in the other list were presented in red. The learning display remained on the screen for 7.8 s, and participants were instructed to memorize all six words. Next, a blank screen was presented for 800 ms, followed by a frame, which was either red or blue, for 1 s (the cue display). The color of the frame indicated which of the two lists just presented would be relevant for making a decision regarding the upcoming probe. Finally, a single word in black appeared inside the red or blue frame (the probe display). Participants' task was to indicate as quickly and as accurately as possible by pressing the appropriate keys on the keyboard whether the word came from the relevant list or not. The computer automatically recorded participants' responses and the latency of their key presses. The probe display remained on the screen until the participants pressed a key to indicate their decision or for 3 s, whichever came first.

Two types of words, negative and positive words, were used in the task. The words were selected from the Affective Norms of English Words (Bradley & Lang, 1999). Positive and negative words (208 words in each valence category) were matched in terms of the arousal dimension and average word length. The words used in the current study were the same words used in Joormann and Gotlib (2008). For each participant, a random sample of words was selected from the positive and the negative lists without replacement in each block.

There were nine different conditions in this task: eight critical conditions and one control condition (see Table 1). Different conditions were created by varying the valence of the words in the relevant list (positive or negative) and the type of probes: relevant probes (i.e., words from the relevant list); intrusion probes (i.e., words from the irrelevant list); new positive probes; and new negative probes. In the eight critical conditions, the red and the blue lists always differed in valence, with each list consisting of either only positive or only negative words. In the control condition (i.e., Condition 9), positive and negative words were mixed within the red or blue lists so that participants could not use the valence of the lists as a cue when responding to the probes. Participants completed a total of 96 trials, which were divided into three blocks and preceded by three practice trials. Each condition was presented four times in each block (i.e., a total of 12 trials per condition), except for the relevant probe conditions (i.e. Conditions 1 and 5). Each of these conditions was presented twice in each block (a total of 6 trials per condition). All possible combinations of color assignment to the positive or negative list and the location (i.e., top vs. bottom) of the blue and red lists were presented equally often within each block. The sequence of trials within blocks and the order of the blocks were randomized.

Questionnaires

Participants completed the Beck-Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), a 21-item self-report measure assessing the severity of depressive symptoms. Participants also completed the brief Fear of Negative Evaluation (FNE; Leary, 1983), which assesses a hallmark feature of SAD. The reliability and validity of both measures have been well documented (e.g., Beck, Steer, & Garbin, 1988; Collins, Westra, Dozois, & Stewart, 2005). In the current study, Cronbach's α for the BDI-II was .96 and for the FNE was .93.

Considering that ruminative tendencies have been linked to deficits in cognitive inhibition (Joormann & Gotlib, 2008), participants also completed the Ruminative Response Scale (RRS) of the Response Style Questionnaire (RSQ; Nolen-Hoeksema & Morrow, 1991). Treynor et al. (2003) identified two subscales, brooding and reflective pondering, that do not overlap with the items on measures of depression, and these two subscales were used in the current study.

Procedure

Participants were tested individually within 2 weeks after their initial diagnostic interview. Participants provided written informed consent after being told that the study was about how people process information. Participants were then introduced to the modified Sternberg task; participants were provided with both verbal and written instructions. Once participants completed the

task, they completed the questionnaires described above. Finally, participants were debriefed and paid at a rate of $15/hour.

Results

Participant characteristics

Demographic and clinical characteristics of the four groups are presented in Table 2. Some individuals elected to skip one or more questions, which is reflected by different dfs associated with different analyses. Although the four groups did not significantly differ in age, $F(3,61) = 1.45$, *ns*, they significantly differed in the gender composition, $\chi^2(3) = 8.26$, $p = .041$. As expected, there were more women than men in the MDD and COM groups, while the two genders were evenly distributed in the SAD group. The CTL group mainly consisted of male participants.[1] The groups also differed in their BDI scores, $F(3, 69) = 29.59$, $p < .001$, $\eta_p^2 = .56$; the CTL group differed from all three clinical groups, all $ps \leq .001$, and the SAD group differed from both depression groups, both $ps < .01$. The COM group exhibited significantly higher BDI scores than the MDD group, $p = .021$. As expected, the groups also differed in their FNE scores, $F(3, 66) = 16.24$, $p < .001$, $\eta_p^2 = .43$; the CTL group differed from all three clinical groups (all $ps \leq .001$), and the MDD group differed from both the SAD and the COM groups, both $ps < .05$. In addition, the groups differed in their self-reported brooding, $F(3, 68) = 13.33$, $p < .001$, $\eta_p^2 = .37$, with the CTL group differing from all three clinical groups, all $ps \leq .001$. Finally, the groups also differed in their self-reported levels of reflective pondering, $F(3, 66) = 2.83$, $p = .045$, $\eta_p^2 = .11$, with the COM group reporting significantly higher levels of reflective pondering than the CTL group.

Modified Sternberg task

We restricted our analyses to trials on which participants made correct responses. A greater percentage of data was lost due to inaccurate responses ($M = 13.92\%$, $SD = 9.61$) than in previous studies, suggesting that the change to limit participants' responses within 3 s limited ceiling effects in accuracy rates as intended. Groups did not differ regarding the overall percentage of data excluded from analyses, $F(3,70) = 1.22$, *ns*.

Decision latencies to relevant probes

Mean RTs for the different conditions are presented in Table 1. For the relevant probes (Conditions 1 and 5 in Table 1), we did not expect any group or valence differences. As expected, a Group × Probe Valence analysis of variance (ANOVA) yielded no significant main or interaction effects.

Decision latencies to intrusion probes (intrusion effects)

Our main hypotheses concern intrusion conditions (when probes were from the irrelevant list). Two types of conditions in the task require 'no' responses: (1) intrusion conditions (i.e., Conditions 2 and 6) and (2) conditions with completely new probes (i.e., Conditions 3, 4, 7, and 8). Regarding the new probe conditions, we were only interested in the conditions in which the valence of the new probe was identical to the valence of the irrelevant list (i.e., Conditions 4 and 7). Thus, the only difference between the intrusion and the new probe conditions are whether the probe initially appeared during the learning display. New probes are easier to reject than irrelevant probes that previously appeared in the learning display; the longer RTs for the irrelevant as compared to new probes reflect difficulties inhibiting irrelevant information from working memory. We expected that the MDD and the SAD groups would exhibit increased interference from irrelevant negative words and, thus, would be significantly slower than controls in determining whether negative intrusion probes came from the relevant list. In contrast, no group differences were expected for decisions about new probes.

We conducted a Group × Probe Valence × Condition ANOVA comparing RTs to intrusion probes versus new probes of the same valence. This analysis yielded only a significant main effect for condition, $F(1, 70) = 263.17$, $p < .001$, $\eta_p^2 = .79$, reflecting the fact that participants took significantly longer to decide whether an intrusion probe was relevant compared to a new probe.

Table 2
Characteristics of participants.

Variables	Group			
	CTL ($N = 18$)	SAD ($N = 17$)	MDD ($N = 19$)	COM ($N = 20$)
Female/Male	4/14	9/8	12/7	13/7
Age	35.88 (8.40)	32.36 (13.64)	41 (12.55)	30.88 (9.99)
Beck Depression Inventory	5.00 (4.91)	17 (10.55)	27.06 (11.49)	34.95 (12.50)
Fear of Negative Evaluation	28.67 (8.83)	47.71 (8.7)	40.42 (11.17)	49.53 (10.58)
Brooding	8.94 (4.19)	13.88 (3.48)	14.39 (3.42)	16.35 (3.70)
Reflective pondering	10.06 (5.01)	12.00 (4.16)	12.82 (3.99)	14.20 (4.42)

Correct responses to relevant probes

Similar to RTs, we did not expect to see any valence or group differences in accuracy rates for relevant probes. Indeed, a Group (CTL, MDD, SAD, COM) × Probe Valence (positive, negative) repeated-measures ANOVA did not yield any significant results.

Correct responses to intrusion probes (intrusion effects)

Although previous research demonstrated group differences in intrusion effects based on RTs (Joormann & Gotlib, 2008), we failed to find such group differences. However, due to the 3 s time constraint that we introduced to the task, participants in the current study did not exhibit ceiling effects for accuracy rates.[2] Thus, group differences in intrusion effects could be reflected in accuracy rates. Everyone is expected to exhibit some degree of interference from intrusion probes. The MDD group, however, would show increased interference from irrelevant negative words and, thus, might make significantly more errors than controls in determining whether negative intrusion probes came from the relevant list. Based on the attention control theory that posits possibly intact working memory *effectiveness* in anxiety (Eysenck et al., 2007), we expected the SAD group to not differ from the CTL group. No group differences were expected for the new probes.

To examine whether groups exhibited different levels of intrusion, we conducted a Group (CTL, MDD, SAD, COM) × Probe Valence (positive, negative) × Condition (irrelevant, new) ANOVA comparing the number of correct responses to irrelevant probes versus new probes of the same valence as the irrelevant probes. There was a significant main effect for condition, $F(1, 70) = 90.73$,

[1] All the results remained the same when we controlled for sex difference among groups with one exception. A significant main effect of group emerged, $F(3,64) = 2.98$, $p = .038$, $\eta_p^2 = .12$, when intrusion effects were examined in terms of accuracy rates. This main effect, however, was qualified by the same significant group × valence effect that we report in the text.

[2] Accuracy rates were lower in the current study compared to a previous study (Joormann & Gotlib, 2008), leading to less trials available for RT analyses. Analyzing RT data using *z*-scores yielded the same pattern of results.

$p < .001$, $\eta_p^2 = .56$, suggesting the expected intrusion effects. Although the 3-way interaction was not significant, $F(3, 70) < 1$, *ns*, the 2-way interaction between condition and group was significant, $F(3, 70) = 3.57$, $p = .018$, $\eta_p^2 = .13$. No other effects were significant.

To better understand the nature of the significant Group × Condition interaction, several follow-up analyses were conducted. As expected, paired *t*-tests examining within-group differences in correct responses to intrusion vs. new probes yielded significant results for all groups, for the CTL group, $t(17) = 6.61$, $p < .001$; for the MDD group, $t(17) = 5.82$, $p < .001$; and for the COM group, $t(20) = 7.57$, $p < .001$; except for the SAD group, whose accuracy for the two conditions approached the traditional level of significance, $t(16) = 1.99$, $p = .064$. Group differences were not significant for the new probes, $F(3,70) < 1$, *ns*. In contrast, the main effect of group for intrusion probes was significant, $F(3,70) = 4.05$, $p = .01$. To follow up, post-hoc LSD tests were conducted. The CTL group was significantly different from both depression groups (i.e., MDD, $p = .02$, and COM, $p = .008$), and the SAD group also differed from both depression groups (i.e., MDD, $p = .034$ and COM, $p = .015$). The two depression groups, however, did not significantly differ from each other, and the CTL and the SAD groups did not differ from each other. These results indicate that both MDD and COM groups made significantly more errors on the intrusion trials than the CTL and the SAD groups (see Fig. 1).[3]

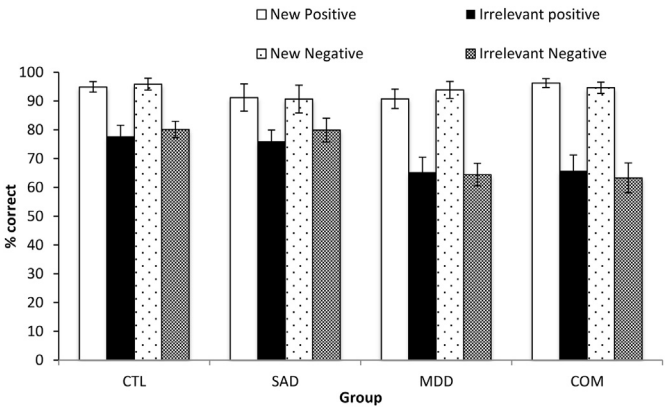

Fig. 1. Mean percentage correct responses. CTL = control; SAD = participants with social anxiety disorder; MDD = participants with major depressive disorder; COM = participants with comorbid major depressive disorder and social anxiety disorder. Error bars represent one standard error.

Rumination and intrusion effects

We examined whether interference from irrelevant material was related to individual differences in the tendency to ruminate. Given that the MDD and COM groups did not differ from each other, we combined the two groups. To facilitate interpretation of results, we created an intrusion index by subtracting the number of accurate trials for the intrusion condition from the new condition of the same valence following Joormann and Gotlib (2008).[4] We computed correlations between the intrusion index and self-reported levels of brooding and reflective pondering within each group. The only significant correlation was between the intrusion index and the levels of brooding in the combined depression group, $r = .44$, $p = .005$. Given the high correlations between brooding and the BDI ($r = .42$) and the FNE ($r = .49$) scores in the combined depression group, we conducted a hierarchical linear regression analysis in which we predicted individual differences in brooding by entering the BDI and the FNE scores in Step 1 and the intrusion index in Step 2. Only the intrusion index ($\beta = .30$, $p = .038$) was a significant predictor of individual differences in brooding in the combined depression group.

Discussion

In recent years, interference from irrelevant negative material has been proposed as a possible mechanism underlying intrusive ruminative thoughts in depression (Joormann, 2010). Given the presence of similar intrusive thoughts in SAD (Abbott & Rapee, 2004; Vassilopoulos, 2008), it is possible that individuals with SAD also exhibit deficits in cognitive inhibition. There are, however, no published studies specifically examining cognitive inhibition of emotional material in SAD. In the present study, we used the modified Sternberg task to examine whether inhibition deficits are specific to MDD or also present in SAD. We predicted that individuals with MDD would exhibit difficulties inhibiting negative irrelevant material replicating previous research (Joormann & Gotlib, 2008). Based on the attention control theory, we predicted that individuals with SAD would not exhibit difficulties inhibiting irrelevant material due to their greater motivation to perform well on the task, when effectiveness aspect of working memory is assessed (i.e., accuracy rates).

Individuals with MDD, regardless of their comorbidity status with SAD, exhibited greater difficulties inhibiting irrelevant material. Specifically, compared to with the CTL and SAD groups, both MDD and COM groups made more errors on the intrusion condition than on the new condition. Thus, individuals with MDD had difficulties inhibiting material that was no longer relevant to the task at hand, leading irrelevant material to interfere with their performance on the task. Greater interference from irrelevant words was also associated with a ruminative tendency. Consistent with Joormann and Gotlib (2008), the relation with rumination was limited to participants diagnosed with MDD and remained significant even after partialing out the levels of depressive symptoms. That is, among individuals with MDD, higher levels of self-reported brooding were associated with greater difficulties in removing task-irrelevant material from working memory. Thus, depression and rumination, brooding in particular, are associated with deficits in updating the contents of working memory. It is important to note that MDD-related inhibition deficits were restricted to negative material in Joormann and Gotlib. It is unclear why inhibition deficits in MDD were not specific to negative material in the current study. More studies are needed to clarify whether depression is associated with expelling any emotional material vs. only negative material from working memory to better address whether depression is associated with general deficits in cognitive inhibition or whether the deficits are specific to negative information.

Unlike individuals with MDD, the SAD group did not exhibit such interference any more than the CTL group. High levels of anxiety might have allowed participants in the SAD group to maintain a level of concentrated effort, which, in turn, helped them effectively perform the modified Sternberg task (Eysenck et al., 2007). This is in line with previous studies demonstrating that participants are better able to ignore irrelevant stimulus characteristics under stress than when they are not stressed (e.g., Chajut &

[3] We reanalyzed both accuracy and RT data with the variable, diagnostic groups, split into two variables: depression and social anxiety. The only significant effect involving either new variables was the interaction between condition and depression for accuracy rates. Thus, the results were consistent with findings based on the analyses using the diagnostic groups as a single variable.

[4] When raw accuracy data were used, only one correlation was significant: the correlation between the brooding scores and the accuracy rates for the trials in which irrelevant stimuli appeared as a probe ($r = -.34$, $p = .038$) in the combined depression group. No other correlations were significant.

Algom, 2003). Comorbid depression, however, seemed to have mitigated any motivational effects of anxiety. This is not surprising considering that depression is associated with "reduced motivation on tasks involving effortful processing" (Porter, Bourke, & Gallagher, 2007, p. 121). The results of the current study suggest that (a) inhibition deficits might be specific to MDD, and (b) participants' comorbidity status might be one of the sources leading to inconsistent findings in working memory functioning in anxiety.

The current results are based on response accuracy whereas results from most previous studies using the Sternberg task are based on RTs (e.g., Joormann & Gotlib, 2008). In previous studies, ceiling effects might have masked any group differences in accuracy. Accuracy rates in the current study were, as intended, notably lower compared to Joormann and Gotlib. To ensure that the task is sensitive to effectiveness aspect of working memory (i.e., accuracy rates), we placed 3 s time restraints for participants to respond. This change led to the intended increase in error rates and revealed group differences in accuracy rates. At the same time, however, the analyses on the RTs in the current study are based on smaller number of trials compared to previous studies due to lower accuracy rates, which could have decreased reliability. Therefore, the RT data might have not been as sensitive to group differences in the current study compare to past research due to the 3 s constraint, and the current version of the task may not be optimal to assess the efficiency aspect of working memory.

Attention control theory (Eysenck et al., 2007) argues that the detrimental effects of anxiety on working memory is more pronounced in processing efficiency than performance effectiveness. Deficits in processing efficiency have typically been conceptualized as longer RTs. In the current study, the SAD group's accuracy rates (i.e., effectiveness) as well as RTs were equivalent to those of the CTL group. The failure to find deficits in efficiency (i.e., RTs) in the SAD group could be due to the 3 s response window. However, other studies have also found that anxious individuals' RTs do not differ from healthy controls (e.g., Walkenhorst & Crowe, 2009). High levels of motivation and effort might facilitate an individual's working memory performance in terms of both accuracy and speed, in which case RTs might not always be an ideal index of processing efficiency. Along this line, a recent study (Basten, Stelzel, & Fiebach, 2012) demonstrated that RTs were not sensitive enough to reveal less efficient processing in anxious individuals. Similar to current findings, anxious individuals did not differ from controls in both accuracy and RTs. Nevertheless, anxious participants exhibited greater activation in the brain areas associated with the goal-directed control of attention, suggesting that they exerted greater neural effort to achieve the same level of behavioral performance (i.e., less efficiency). Therefore, RTs might not be an ideal index for deficits in working memory efficiency.

Cognitive inhibition of irrelevant *emotional* material has been an understudied area in anxiety research. Although results from the current study suggest that cognitive inhibition is relatively intact in SAD, it remains an empirical question whether other anxiety disorders share this particular characteristic. Considering that SAD frequently precedes the onset of MDD (e.g., Ohayon & Schatzberg, 2010), it would be interesting for future studies to longitudinally examine whether the level of cognitive inhibition in individuals with SAD could predict who would develop comorbid MDD or whether deficits in cognitive inhibition are simply sequelae of MDD. Although results are generally consistent with previous findings and the attention control theory (Eysenck et al., 2007), it should also be noted that the findings are based on relatively small number of participants and, thus, require further replication. Lastly, the selection of the stimuli used in the current study might have obscured any social anxiety-related deficits. Although we did not use depression-specific stimuli, it is possible that semantic material is better suited to find depression- or rumination-related deficits than social anxiety-related deficits.

Clearly, more studies are needed to investigate whether inhibition deficits in depression are shared by anxiety disorders or not. However, the current study is first to directly compare individuals with MDD vs. SAD and to demonstrate that inhibition deficits might be unique to depression. Individuals with SAD seemed to be able to exert enough effort to overcome anxiety-linked deficits, if any, leading to a level of performance comparable to healthy controls. Interestingly, when SAD is comorbid with MDD, diminished motivation generally associated with depression seems to negate any positive effects of anxiety. Despite sharing many commonalities, SAD might be differentiated from MDD in its intact ability to remove irrelevant information from working memory.

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